Historic, archived document

Do not assume content reflects current scientific knowledge, policies, or practices.

CIRCULAR No. 166 JUNE, 1931
UNITED STATES DEPARTMENT OF AGRICULTURE
WASHINGTON, D. C.

SUGGESTIONS FOR THE IMPROVEMENT OF OLD BANK DAIRY BARNS

By M. C. Betts, *Senior Architect*, and M. A. R. Kelley, *Associate Agricultural Engineer, Division of Agricultural Engineering, Bureau of Public Roads* [1]

CONTENTS

	Page
Introduction	1
Purpose of investigation	2
Prevailing conditions	2
Common type of barn	2
Improvement of old barns	8
Light	8
Artificial light	14
Ventilation	14
Stalls and equipment	20
Stall arrangement	22
Improvement of old barns—Continued.	
Stall fastenings and partitions	24
Water bowls	25
Litter carriers	25
Haymow framing	25
Repairs	26
Suggested remodeling of a barn	27
New barn construction	30
Summary	33
Literature cited	34

INTRODUCTION

Municipal authorities in many of the larger centers of milk consumption have set up rigid requirements for producers shipping milk into those centers. Such regulations prescribe clean, light, sanitary stables; clean utensils; clean, healthy animals; and careful handling by disease-free labor as essential to a safe milk supply. A clean, wholesome farm-water supply and proper disposal of sewage are also important factors in the safeguarding of public health.

In many of the milk-producing areas, particularly in portions of the Middle Atlantic and North Central States, there are a great many dairy barns that do not conform to the standards established in many States or to the requirements of the markets supplied. A large number of these barns were built years ago, before the necessity of cleanliness and health of milk cows was realized. In fact, many of them were built to house beef cattle rather than dairy cows and were converted to the latter use. Certain construction practices were developed and handed down so that even to-day new barns are built along old lines not adapted to good milk production. The old type of barns is generally wasteful of space and materials. Poor arrangement and lack of modern time and labor-saving equipment account for high operating and maintenance charges that seriously affect the farm profits. The most serious objection, from the structural standpoint, is the lack of light, ventilation, and cleanliness which are necessary to the health of the stock. These old barns are often in good

[1] In cooperation with the department of farm machinery, Pennsylvania State College, Philadelphia Interstate Dairy Council, and Bureau of Dairy Industry, U. S. Department of Agriculture.

condition. They must be used, for few owners can afford to abandon a substantial structure representing a considerable investment to build a new barn of approved type.

PURPOSE OF INVESTIGATION

This circular is based upon a survey of the conditions under which milk is produced in southeastern Pennsylvania. It was prepared at the request of the Philadelphia Interstate Dairy Council and in cooperation with the council and the department of farm machinery of the Pennsylvania State College. The purpose of the investigation was to study these older dairy barns in southeastern Pennsylvania with a view to making recommendations for improving the conditions under which milk is produced in that area. The types of barns observed and the general conditions under which milk is produced in that section are also to be found in other milk-producing sections of the country. The suggestions in the following pages apply with equal force wherever similar conditions exist.

PREVAILING CONDITIONS

The area under consideration is entirely favorable to milk production. The growing season is longer, the winters are milder, and there is less danger of drought than in any other part of the State. The abundant rainfall and rolling character of the land account for many running streams, green pastures, and hay lands. These natural conditions, together with the proximity of large market centers, are important factors in successful dairying.

During the winter months there is an average of less than 100 days when the minimum temperature is below freezing, and zero temperatures seldom occur more than once or twice a year. However, the humidity is generally high, and temperatures of 10° or 15° F, with 80 per cent relative humidity are quite common. The combination produces a raw, penetrating atmosphere which causes discomfort and suffering among animals as well as human beings, and makes warm, comfortable shelter necessary for the dairy cow whose energy must be devoted to the production of milk.

COMMON TYPE OF BARN

The type of barn common to the region is the result of ideas and farming practices prevailing more than 100 years ago, at a time when building materials and labor were cheap and plentiful. Evidence of the prodigal use of material is found in the heavy stone walls, often 2 feet or more in thickness, and in the heavy timber framing.

The typical barn, known locally as the Swiss, Dutch, or Pennsylvania "overshot," because of the peculiar overhanging construction, was in its earliest form built as shown in Figure 1. The sills, or beams supporting the overhang were hewn logs unsupported at the outer ends. As saw mills became more general, heavy timber framing covered with boarding, as illustrated in Figure 2, was employed in the barn superstructure in place of stone masonry. Later the beams under the overhang were supported by girders resting

on heavy stone or brick piers or on wood posts as in Figure 28. The interior view of a hay mow (fig. 3) illustrates the heavy framing employed to support the roofs of these barns.

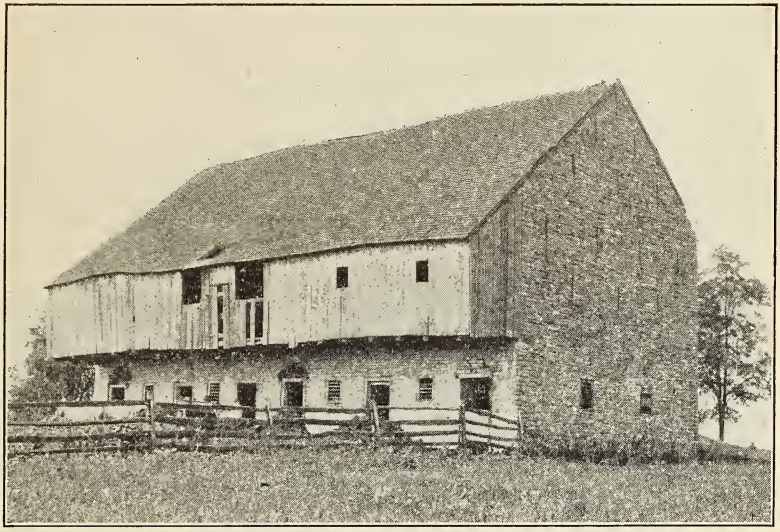

FIGURE 1.—An old stone barn with overhang

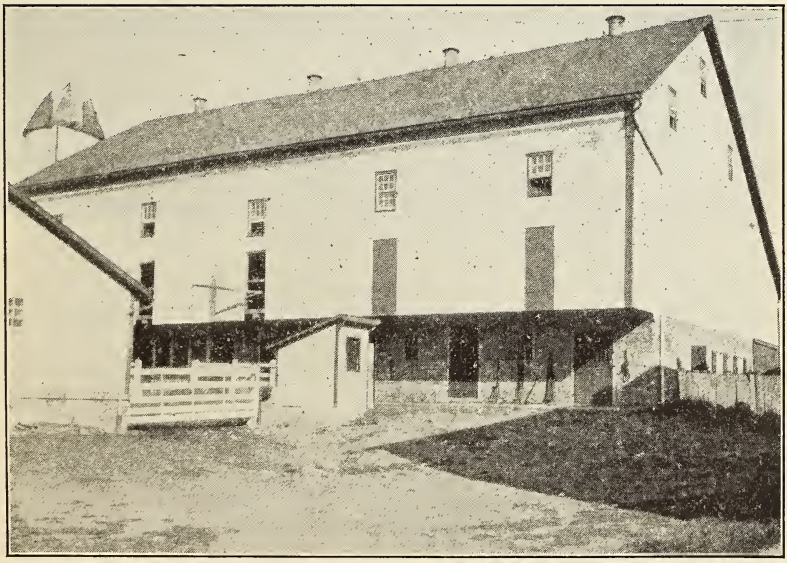

FIGURE 2.—A timber-framed barn with overhang

Most of these old barns were built into a hillside with one side of the lower story wholly or partly below ground level. These are known as bank barns. In many instances the structure stands on gently sloping ground with a runway or bridge to the mow floor.

The runway consists of an inclined fill of earth sometimes supported at the sides by heavy retaining walls. This driveway to the mow floor was a necessity when hay had to be unloaded with hand forks. It is still considered so by many farmers who have built new barns along the old lines but equipped with modern hay-handling apparatus. The reason given is that two or three loads of hay can be run into the barn in case of a sudden rain. The mow-drive space is also used for the storage of wagons and implements.

The practice is very uneconomical. With modern hay-handling equipment hay can be stored at less cost from the outside through gable-end doors. A few square yards of tarpaulin thrown over a load of hay will protect it from rain. Not only is the tarpaulin a much cheaper protection but by its use loaded wagons may be protected in the field. It may also be used as temporary covering for

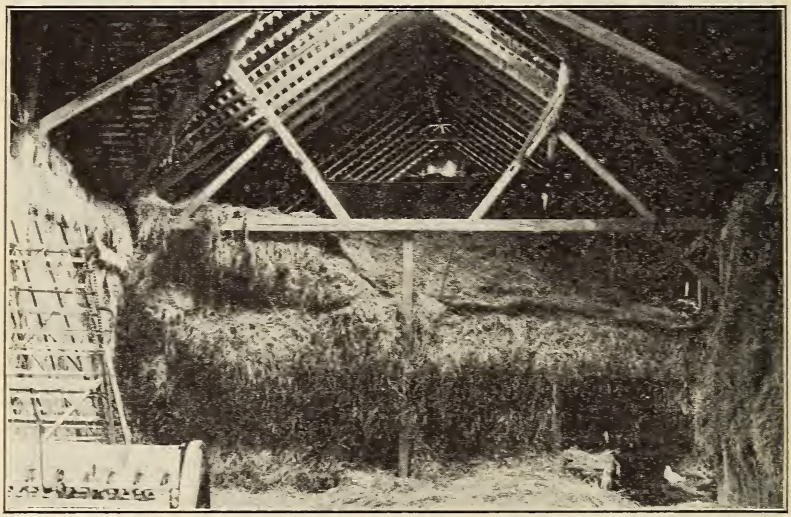

FIGURE 3.—Example of timber roof framing found in many old barns

grain stacks, machinery, and other property. The housing of wagons and machinery on the mow floor takes valuable floor and overhead space and is most inconvenient because of the lack of handling space. In case of a mow fire anything stored in the driveway is an assured loss, and without equipment farming operations are seriously hampered. These considerations, together with the desirability of light and air on all sides of the stables, make the use of the so-called bank barn or that with a mow runway or bridge, generally inadvisable from the economic standpoint, unless the upper floor is to be used for the storage of other crops, such as tobacco, apples, or potatoes, as is the case in some sections.

In most of these barns the stock is arranged in the lower story in rows at right angles to the bank wall, with alley doors opening into the space under the overshoot, which serves as a covered passage between the feed and litter alleys. Stalls, mangers, and stanchions of wood, often in bad condition and always difficult to keep clean, are common. Figure 4 is a view of a row of stalls in an old barn.

The wooden box mangers can not be kept clean, and they provide harborage for rats and other vermin. Floors of dirt, stone, or planking, saturated with liquid manure and which can not be kept clean, are frequently found. The dark, damp stables with walls and ceilings covered with cobwebs and dust are not conducive to health in the animals, nor do they inspire those attending the stock to cleanliness and care in handling the milk, a factor which is absolutely essential to success in dairying.

Straw for bedding is generally stored in the overhanging part of the mow and is dropped to the ground below to be carried into the stalls. In some instances this straw storage is not a true overhang but is attached to the barn proper. (Fig. 5.) Any overhanging construction, whether supported by posts or not, makes

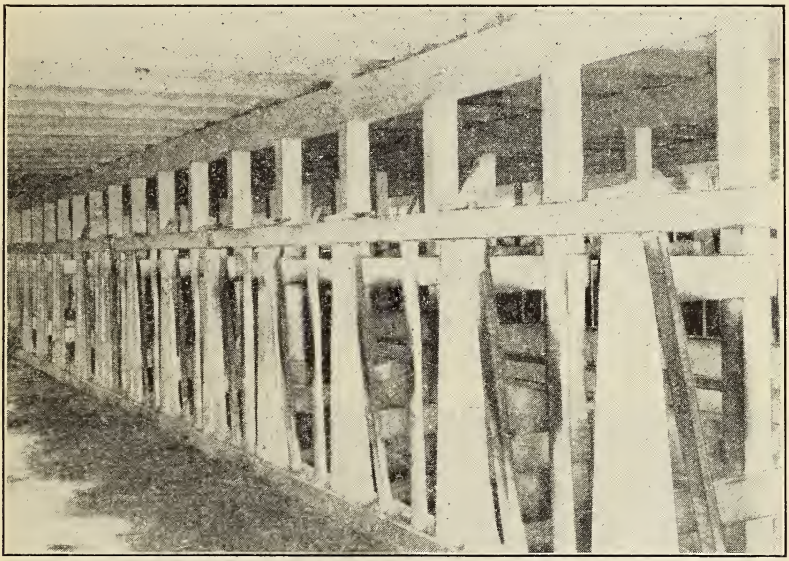

FIGURE 4.—Interior view of old barn. The multiplicity of wooden posts and rails, even though whitewashed, makes the stable dark and interferes with air circulation

the stables dark, and for this reason alone is very undesirable. Figure 6 is evidence of the effect of "overshoots" upon the light in the stables.

When old barns are destroyed by fire or storm they are often rebuilt on the old foundations and in the old manner of framing. This results from a desire to save expensive foundation work and from the inexperience of local carpenters with modern framing methods. Instances are known in which long, heavy timbers have been shipped from far Western States for use in old-type framing when modern framing would have permitted the use of smaller and more readily available sizes of lumber. Analysis of old-type framing generally shows it to be wasteful of material. Floor beams 8 by 8 inches or 8 by 10 inches spaced 2½ feet on centers were used when 2 by 10 or 12 inch joists spaced 2 feet on centers would carry the imposed load. Large, heavy, solid timbers are used as girders when four or five pieces of 2 by 10 or 12 inch lumber

may be spiked and bolted together to serve the same purpose. Heavy, solid, mortised and tenoned timbers are used in wall and

FIGURE 5.—An overhanging shed supported on stone pillars

FIGURE 6.—View showing how barn light is cut off at midday

roof framing when plank-frame construction employing 2-inch lumber requires less material and can be erected with less labor.

Very frequently heavy beams are placed with the lesser dimension vertical, an uneconomical practice originating with the use of tree trunks adzed on two sides to provide bearing surfaces. There is a rough rule that doubling the width of a given timber doubles the strength, but doubling the height increases the strength four times. A square timber is often used when one of less width but greater height and of less cross-sectional area would carry the same load. Thus an 8 by 12 inch beam with the 12-inch side vertical will carry 21 per cent more than a 10 by 10 inch beam, yet the former contains 4 per cent less material than the latter. If the beam were placed with the 8-inch side vertical it would support but three-fourths as much weight as the 10 by 10 inch beam.

The true "overshot" construction—that is, without posts or piers under the outer wall—makes very expensive storage for hay or straw. The heavy cantilever beams required are an uneconomical form of support because of the size of the beams and the substantial anchorage that must be provided at their inner ends. Beams supported at the outer ends require much less material and erection labor. A comparison of the two principles is shown in Figure 7.

FIGURE 7.—A, Cantilever beam supporting a given load W; B, beam of same dimensions supported at both ends and capable of supporting 4W or four times the load on A

Little or nothing need be done by way of remodeling the superstructures of old barns, but in most instances the stables, while not susceptible of being made ideal, can be better lighted and ventilated. They can be rearranged and equipped so as to be more easily kept in a good sanitary condition and thus afford a better environment for high-producing stock.

There have been many changes in animal-husbandry practices since these old barns were built. The beef cattle with a few milk cows which they housed in the early days, gave place to dairy cows yielding 2,000 pounds or less of milk per year. Better breeding and handling increased the yield until now there are several herds in the region surveyed in which the average yield per cow is more than 10,000 pounds.

Dairy herds require more labor than do any other class of livestock, and as the milk yield is increased more and a better class of labor is necessary, greater care in feeding and handling must be employed and use must be made of every means of conserving labor and feed.

Improper stabling and care are contributory causes of disease and are factors in the dissemination of tuberculosis wherever the germs are present. The stabling of cows in dark, damp, poorly ventilated barns may affect their health. Continued breathing of

foul, damp air may lower the vitality of the animals and render them more susceptible to the attack of disease germs. Pulse and respiration in the high-producing cow are appreciably faster than in the low-producing animal. The strain induced by poor environment should not be added to that incident to the effort of high production. Hence it is obvious that if the production of milk in these old unsuitable barns is to be improved, changes must be made, and that the sanitary conditions must have first consideration.

IMPROVEMENT OF OLD BARNS

Prevention of disease depends largely on observance of the ordinary laws of hygiene prescribed by physicians for human beings and applying with equal force to the care of animals. The principal requisites are the following: (1) An abundance of clean water, clean wholesome food, well-regulated bowels; (2) fresh air night and day; (3) as much exposure to sunlight as possible; (4) avoidance of chilling and overheating; and (5) avoidance of crowded quarters.

The primary object to be sought in remodeling the barns under consideration is improvement in lighting, ventilation, stall floors, and equipment, together with structural repairs necessary to the preservation of the building.

It is not possible within the limited space of this circular to consider the conditions in each of the barns surveyed. Suggestions of more or less general application are offered together with a few illustrations of remodeling which has been done and from which others may obtain ideas applicable to their own conditions. Owners of old barns can obtain many helpful suggestions by visiting near-by barns that have been improved; from bulletins of the United States Department of Agriculture, from literature of barn-equipment manufacturers, and from manufacturers of building materials.

LIGHT

Sunlight is a potent agent in the prevention as well as the cure of disease. It lowers the vitality of all germs and actually destroys many kinds. On the other hand it stimulates the growth of body tissue; its value in the curing of rickets is well known. Sunlight exposes dirt which might otherwise be overlooked; it makes for warmth and dryness and reduces the spoilage of feed; and it expedites the work. It is hardly possible to get too much light into these old stables.

The principal factors affecting the natural lighting of stables are the number, size, and arrangement of windows, thickness of walls, height of ceiling, and character of wall surfaces with respect to light reflection. Two commonly used rules for determining the amount of glass required are "4 square feet per stall," and "1 square foot per 25 square feet of floor space." These do not insure adequate lighting unless the glass is so placed as to distribute the light uniformly.

Figure 8 illustrates the effect of wall thickness on light distribution. In A the first rays of the morning sun entering through the window strike an assumed interior wall at *a*. As the sun advances

the light travels along the wall until the last rays in the afternoon strike the wall at *b*. In B the earliest and latest light rays strike the wall at *c* and *d*, respectively, if the masonry jambs are square. By beveling the inside jambs the light distribution on the assumed interior wall is increased to *e* and *f*, about equal to that of the light entering through a window in a frame wall. With the removal of the assumed interior wall the sunlight would travel over corresponding areas of floor, gutter, and manger surfaces, drying up moisture and destroying disease germs. The same principle of distribution applies to daylight entering a window in any position and irrespective of the direct rays of the sun.

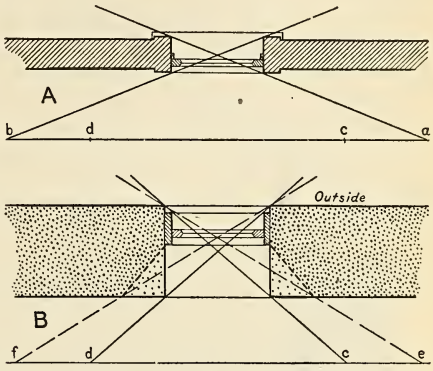

FIGURE 8.—Effect of wall thickness on light distribution: A, Plan of a window in a frame wall, facing south, 9 inches thick at the jamb; B, window of same width in a 22-inch masonry wall

It is obvious that as one means of providing more sunlight in old barns with masonry walls the jambs of existing windows may be beveled. Wherever possible, additional windows should be provided. The location will depend upon the existing construction.

It is apparent that more light is admitted from two windows placed in a single wide opening, particularly in a masonry wall with square jambs, than when placed in two separate openings. The labor involved is less, since, if an existing opening is enlarged to receive a new window, there is but one new masonry jamb to be built, whereas when a new single opening is provided, there are two jambs to be dressed, squared, and plumbed.

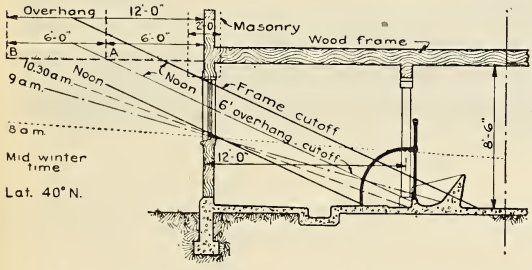

FIGURE 9.—One-half cross section of a dairy stable 36 feet wide showing direction of the sun's rays at various morning hours and the extent to which overhanging construction affects the entrance of sunlight into the stable

The number of hours during which direct sunlight will pass through a window depends upon its position in the barn, the time of the year, and the latitude. During the winter months the greatest amount of light will enter through south windows. Southeast and southwest windows will admit 71 per cent, and east and west windows 21 per cent, of the amount of sunlight entering south windows during this period of the year.

The intensity of the sun's effect at noon may be more than twice that at 9 a. m. Overhanging construction shuts out sunlight during the middle of the day when it is of the greatest value. The extent to which this may occur is shown in Figure 9. The dotted, dot-and-

dash, dash, and solid lines represent the direction of paths or bands of direct sunlight which, at midwinter in the latitude of the region under consideration and at the hours indicated, would enter a south window having nine 9 by 12 inch lights and placed at the usual height in a frame wall, provided there were no obstruction. It is readily seen that at 8 a. m. the entire window opening would receive sunlight. Although this would be helpful, so far as light in the interior is concerned, the radiant heat of the sun at that hour would have little effect. After 10.30 a. m. the direct rays of the sun would be entirely cut off by the 12-foot overhang indicated. Thus from 10.30 a. m. until after 1.30 p. m., the period when they are of the greatest benefit, direct rays of the sun could not enter the stable. At noon, even a 6-foot overhang would cut off one-half of the sunlight that normally would enter the window.

FIGURE 10.—Remodeled barn in which a new wall with a number of windows was built under the outer walls of the overhang

Lowering the window would admit more sunlight, but this would not be desirable from the standpoint of general light distribution, ventilation in warm weather, and risk of breakage.

In a number of instances owners have materially increased the amount of light admitted to the stables by removing the wall, substituting post and girder construction, and building a new wall with ample windows under the outer wall of the overhang, as was done in remodeling the barn shown in Figure 10. Where space permitted the stalls were rearranged so as to place the stock as near as possible to the newly installed windows. In other instances the overhang has been removed. If an owner feels that he must have some shelter from the weather in passing from alley to alley, a light shed roof projecting about 6 feet could be substituted for the overhang, but it should be placed high enough not to shut off winter sunlight from the stable.

Wherever possible, small windows should be enlarged and new windows added. In some instances it may not be feasible to install

more than one or two new windows in the walls of the stable. In such cases it is often possible to provide more light by placing windows in the walls of the mow above and cutting openings in the mow floor, as suggested in Figure 11. At low outside temperatures the moisture in the air, which will gather in the pocket formed by the window housing, may condense upon surrounding surfaces, causing dampness and rotting of woodwork. To prevent this, the window sash, at least those on the north side, should be double, and the housing well insulated. A good covering of hay would serve the purpose.

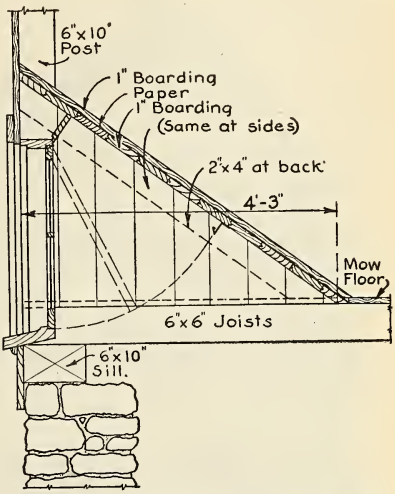

FIGURE 11.—Method of introducing light into stable from above the mow floor

A decided improvement in stable lighting is shown in Figure 12. Figure 13 shows how the lighting was improved in another barn where the conditions were somewhat different. Small windows in the masonry wall shown in Figure 14 were enlarged. The windows to be seen in Figure 15 were added at the end of the stable. The long narrow windows above the masonry in Figure 14 were inserted between the heavy girders shown

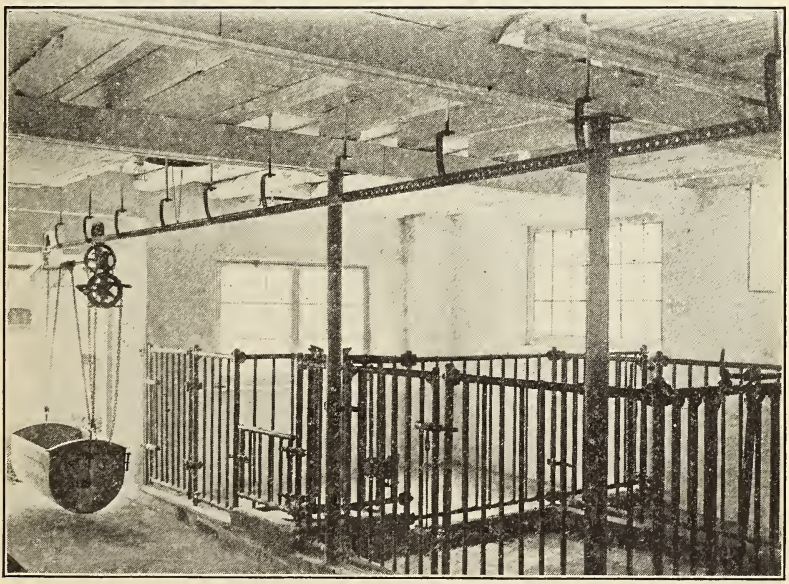

FIGURE 12.—Interior of barn, shown in Figure 10, which is now well lighted

in Figure 15. The latter illustration shows how the light entered at noon on an October day. Direct rays of the sun now fall on the

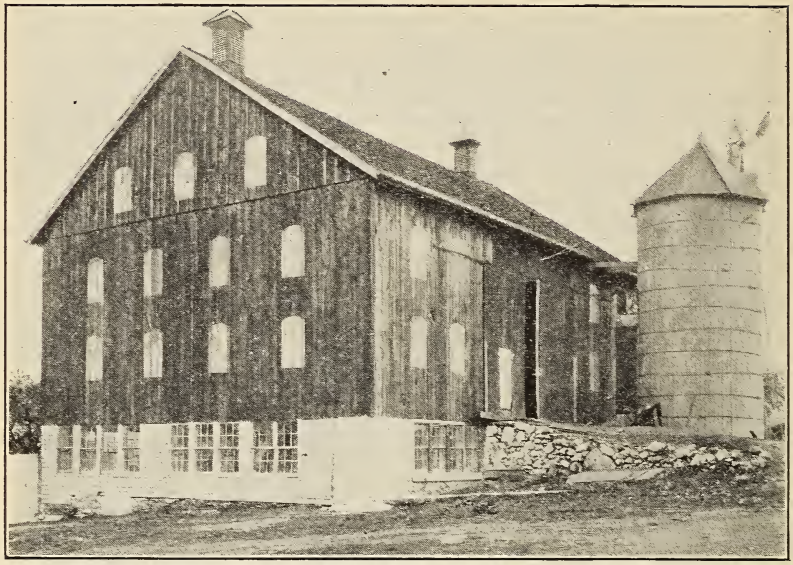

FIGURE 13.—Exterior of remodeled barn showing newly installed windows at side of driveway. A portion of the end stone wall was removed and frame construction substituted with additional windows

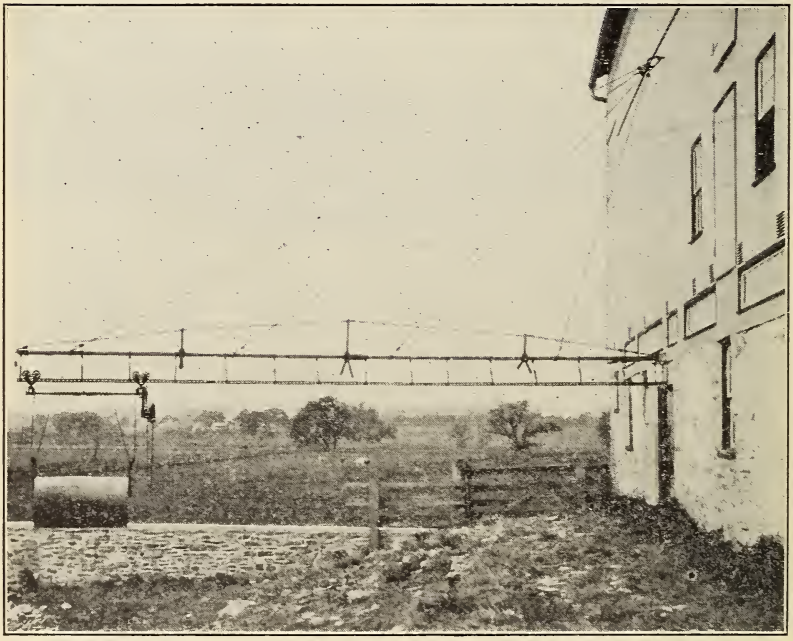

FIGURE 14.—Exterior of remodeled barn showing newly installed windows and litter carrier

litter alley and gutter, while the general lighting of the stable has been greatly improved. More windows could have been added to advantage in the masonry wall as the stable is unusually wide (40 feet) and high. Since the barn is of the bank type it was not possible to provide windows on the bank or dark side except at considerable cost for excavating, so that even with the added windows the lighting is not what it should be.

The metal stanchions shown in Figure 15 replaced old wooden stalls which it was impossible to disinfect properly and which required frequent whitewashing. Hay racks extending to the ceiling above the mangers prevented the diffusion of light from windows

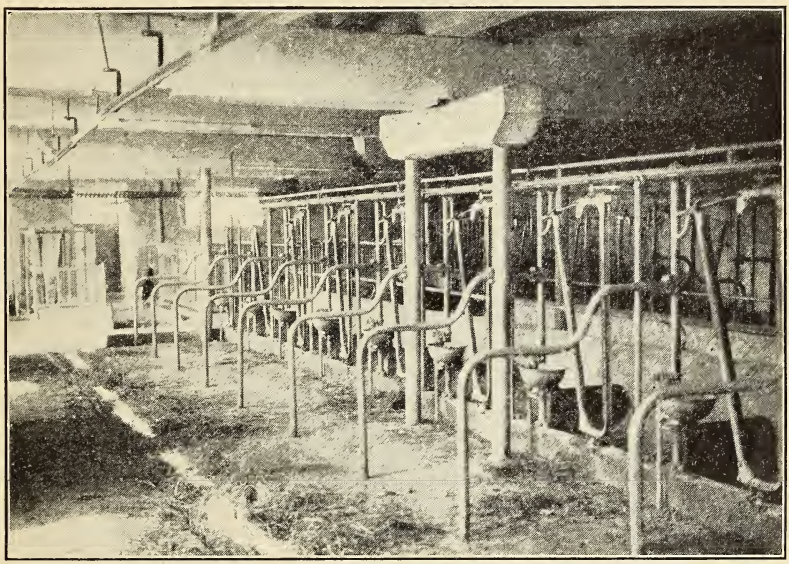

FIGURE 15.—Interior of barn shown in Figure 14. The stalls were rearranged, and two posts were substituted for one which interfered with the stall spacing

and seriously interfered with the air circulation necessary to the removal of dampness.

The benefits derived from the installation of additional windows are greatly impaired if the glass is allowed to become and remain covered with cobwebs and dirt. A very little dirt will reduce the light to one-half or one-fourth of that passing through clean glass. Windows should be kept clean, particularly during the fall and winter months when sunlight in the stables is of the greatest importance.

Light entering through windows strikes wall and other surfaces which, if of proper character, reflect it in various directions. In this way dark places not exposed to the direct light are benefited. All interior surfaces should be made as smooth as possible and kept well painted or whitewashed. Not only does whitewash improve the lighting of a barn, but each new coat has some value as a disinfectant as it tends to prevent or retard the growth of bacteria and mold (*3*).[2]

[2] Italic numbers in parentheses refer to Literature Cited, p. 34.

One-third of the barns of shippers supplying milk to one station were found to be badly in need of whitewash.

The application of whitewash with a hand brush is a disagreeable task, particularly on overhead surfaces. A power sprayer scours and cleans the surfaces and applies the whitewash quicky and thoroughly. Places difficult to reach with a brush are easily sprayed. In some sections of the country, spraying outfits are owned by cooperative associations and are available to members. In one locality visited during the survey whitewashing was being done under contract with the owner of a power outfit.

ARTIFICIAL LIGHT

Much, if not most, of dairy-barn work is done before sunrise and after sunset. Ample and reliable artificial light makes for efficiency and speed in getting the chores done. Experimental data show that good lighting reduces the time required by from 25 to 40 per cent. Many owners, where current is available, have installed electric lights. Others have found it profitable to install individual electric plants. Because of the fire hazard, all electrical wiring and appliances should be installed in strict accordance with the National Electric Code (*6*).[3] Owing to the dampness and ammonia fumes present in many old barns, the accepted methods of wiring differ somewhat from those employed in house wiring. Meters should be placed where there is no likelihood of dampness. Wiring in hay lofts should be run in sheathed cables. If rigid conduit is used, it, together with all fittings, should be of rust-proof material and should be pitched to proper drainage points to care for any condensation that may occur.

All barns should be protected from lightning. There is no question concerning the value of properly installed lightning-protective systems (*2*). The installation of all wiring and lightning-protective systems should be done only by those experienced in the work.

VENTILATION

Cows, as do all animals, give off heat and in breathing produce certain gases and moisture. Odors which are apt to affect the quality of milk are given off by manure and certain feedstuffs. The continuous breathing of foul air is not conducive to health in the animals. The purpose of a ventilation system is to remove the products of respiration, to introduce clean fresh air, and to keep walls and other surfaces and feedstuffs dry. Adequate ventilation is required by regulations governing the production of market milk.

The heat given off through the skin of the animals and in expired air warms the stable air which tends to rise. Fresh, colder air entering the stable is heavier than the stable air and falls to the floor. As it is warmed it rises, thus setting up a circulation. All air contains moisture. As its temperature is increased so is its ability to hold moisture. Cool outside air brought into the stable and warmed absorbs moisture from the stable air and from wall and other surfaces. If the ventilating system is properly installed and operated,

[3] The National Electric Code may be obtained upon application to the National Fire Protection Association, 60 Batterymarch Street, Boston, Mass.

the temperature and circulation of the air in the stable can be controlled provided the barn is tightly and warmly built. A more comprehensive explanation of the principles of barn ventilation and the construction of barn ventilating systems is to be found in Farmers' Bulletin 1393 (*5*).

The chief difficulties with regard to the ventilation of these old bank barns were found to be overcrowding of stock, in some instances an insufficient number of head; excessive dampness; the lack of, or faulty location of air-inlet openings; and construction and arrangement which made installation of outtake flues something of a problem.

Overcrowding of stock results in the production of a large volume of foul air making necessary an abundant supply and good distribution of fresh air, which is often difficult to obtain because of the arrangement and construction of the barn. Too small a number of cows means that each animal must heat an undue volume of air. In the locality under consideration the volume of air space in the stable should not be more than 900 nor less than 500 cubic feet per cow.

Dampness is due to seepage of ground water through floors and masonry bank walls, and to the condensation of moisture in the stable air as it comes into contact with cold surfaces, principally the masonry walls which lack insulating value. The complete remedy lies in damp-proofing the walls, the addition of insulation to the wall construction, and proper ventilation. The prevention of seepage, and the furring of the outside walls with insulating material, are impracticable in most instances because of the cost. In some cases the infiltration of surface or ground water might be overcome at comparatively little expense. Suggestions of value in this connection will be found in Farmers' Bulletin 1572 (*8*).

Depending upon the nature of the material, masonry walls transmit heat from five to twenty times more rapidly than does wood of the same thickness. In colder climates the insulating of masonry stable walls is necessary to the maintenance of proper stable air conditions. In the region included in this investigation it is desirable but not so essential, particularly when the walls are very thick. The construction should be tight so that there is no air leakage through joints in the masonry and around doors, windows, sills, etc. Wherever there is leakage of cold air there is apt to be condensation of the moisture in the stable air upon surrounding surfaces, causing dampness and rotting of woodwork. Leakage of cold air lowers the temperature of the stable air and interferes with the control of air circulation by means of the ventilating system.

WINDOWS

Good ventilation requires that there be free and evenly distributed circulation of air in all parts of the stable. It is difficult, and in many cases impossible, to obtain good circulation of air in bank barns because the openings through which air might enter the stable are generally all on one side. There are many mild days during the winter when ventilation may be had by means of open windows, but for effective ventilation there must be openings on opposite sides of the stable. Even with a fairly strong wind, air will not enter the

windows on one side in any volume unless an equal amount can escape on the other side. Usually the bank side offers the greatest difficulty in providing additional windows for ventilation. When the entire or greater length of the stable wall is below grade the method shown in Figure 11 may be employed. Windows below the grade level and opening into areas may be installed, but they are not advisable because the areas may collect water or become filled with snow.

When the bank wall is but partly below grade windows may sometimes be installed between the grade and the mow-floor level. Where access to the mow floor is by a bridge or embanked driveway the wall under it is without windows and it is usually at this point that light

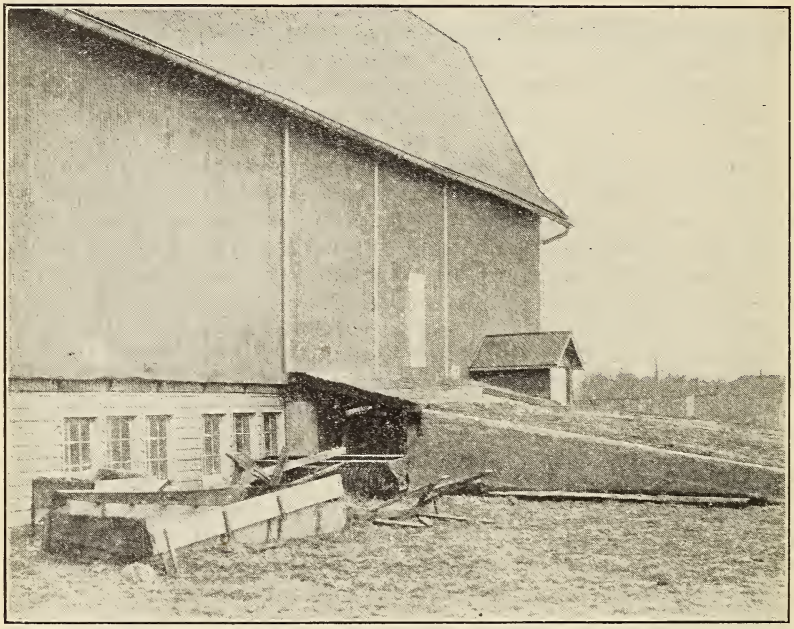

FIGURE 16.—An example of a bridged driveway. Windows under the bridge provide ventilation and some light

and ventilation in the stable are most needed. If the approach consists of a bridge, windows may be installed under it as shown in Figure 16. In many instances a filled-in driveway can be cut away for a distance of 8 or 10 feet from the wall and a bridge erected to span the cut. Windows in such a position do not add much to the lighting of the stable but aid greatly in air circulation. All windows should be hinged at the bottom and drop inward at the top with cheek pieces at the sides to direct the incoming air upward.

In many instances where the bank wall is entirely or mostly below grade, the bank may be cut back 8 or 10 feet and deep enough to permit of the setting of windows in the wall, as shown in Figure 17. A bridge to the mow floor could be built to replace the drive.

Ventilation by means of open windows is permissible and even desirable during mild weather, but when the outside temperature is

below freezing, proper ventilation by this means is impracticable. The movement of air through open windows can not be controlled without constant adjustment of the openings, so that even distribution of incoming air and maintenance of stable temperature are impossible, particularly in these old bank barns where the windows are generally confined to one side. To obtain proper ventilation during cold weather suitable intake and outtake flues, placed so as to produce even distribution of fresh air, are necessary. During mild weather, when window ventilation is permissible, intakes, installed where windows are not feasible, will aid in obtaining air circulation.

OUTTAKE FLUES

Outtake flues were entirely lacking in many of the barns visited. In most instances where outtake flues were found the installation was faulty. Generally the flues were but one-half the size required, were poorly built, had many cracks through which air leaked, and had too many crooked runs and right-angle turns. The location in many cases was such that, even had the flues been of proper size and construction, there would have been little or no air circulation along the bank side of the stable where it is usually most needed. The mow driveway and the necessity of keeping it free of obstructions frequently prevents the placing of an outtake so as to stimulate air circulation in this part of the stable. Where such a condition exists the proper installation of an electric fan would provide air movement. The location of outtakes depends upon the conditions existing in the particular barn. In general there should be one outtake to every 10 or 12 cows so placed as to produce equal distribution of incoming air.

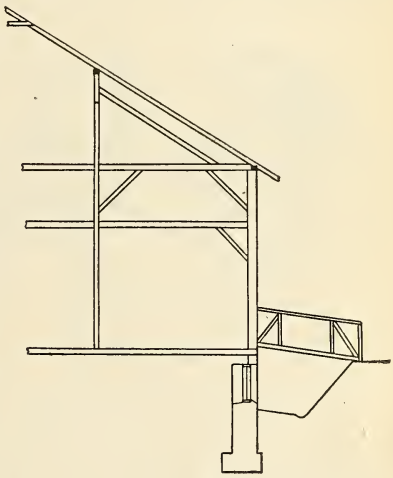

FIGURE 17.—Part cross section of bank-barn wall and bank cut away to admit light and air

SIZE OF FLUES

The size of the outtake flues depends upon the height and the temperature conditions in the locality. The height of the flues is fixed by the distance from the ceiling of the stable to the ridge of the roof, which, in most of the barns in the region studied, is between 30 and 40 feet. According to a recently developed method of determining flue sizes, the area of outtake flue in the region under consideration should be 38 square inches per head of stock for a flue 30 feet high and 33 square inches for a 40-foot flue. Areas of flues of heights other than those given may be obtained by the

formula $A = \frac{163 + 1.6t_0}{\sqrt{H}}$ in which A is the required area in square inches per head of stock, t_0 the mean January temperature for the locality, and H the height of flue in feet. In this section, where the mean January temperature is 30° F., the formula becomes $A = \frac{211}{\sqrt{H}}$.

CONSTRUCTION OF FLUES

Flues must be air-tight, or they will not draw properly, and well insulated to minimize condensation of moisture on the inner surfaces. They may be of any durable material, but matched lumber or rust-resisting metals are generally used. The construction of wooden and metal flues is illustrated in Figure 18. The metal lining of flues A and C protects the insulating material from the con-

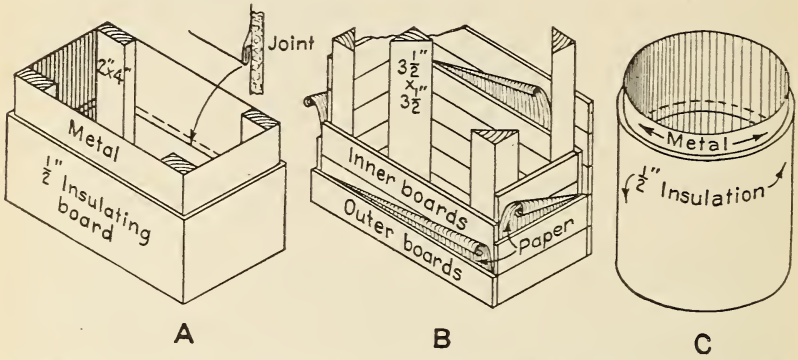

FIGURE 18.—Construction of outtake flues: A, Rectangular metal flue on wooden frame and covered with insulating board; B, rectangular wooden flue of matched lumber and paper; C, insulated round metal flue

densation which occurs to some extent in all outtake flues. The frame of 2 by 4 inch studs in A is less desirable than the frame of triangular pieces shown in B, as it offers greater resistance to the passage of air. However, unless a power saw is available, either on the farm or at the lumber yard, the ripping of square lumber is hardly warranted.

As cross bracing or cleats on the inside of the flue tend to retard the passage of air horizontal joints in the metal should be made as in the small detail in A. This joint, if well made, is practically air-tight and will not permit condensation drip to leak into the insulation and impair its value. The waterproof building paper shown in B prevents air leakage through the joints of the boarding. If all the lumber is painted or treated with creosote, the life of the flue will be greatly increased.

The round flue, C, is more efficient than a rectangular one, but is not so readily built by the average workman. The flue is made in sections and put together with slip joints, each section being fitted into the one below so that condensed moisture will flow to the bottom of the flue.

INTAKES

Intakes may be installed in frame walls with much less difficulty than in the masonry construction common to the type of barn under consideration. Ordinarily, an intake is a rectangular duct with a vertical leg of 5 feet or more in length and forming a trap which tends to prevent or reduce back drafting, that is, the outward movement of warm stable air. The fact that the vertical leg does not always prevent back drafting has led to the development of commercial intakes equipped with valves which automatically regulate the amount of the entering air and prevent the escape of warm air from the stable. They may be built into a wall or into a short horizontal duct.

Several methods of installing intakes in connection with stone walls are shown in Figure 19. The method shown in A may be used when the ground level is not too high above the stable floor

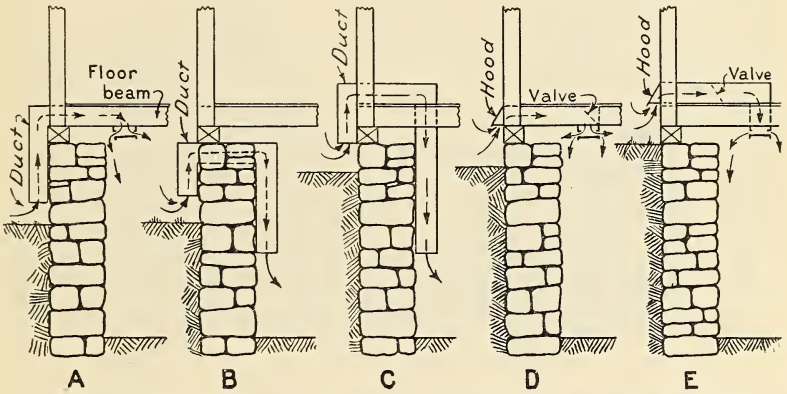

FIGURE 19.—Methods of installing intakes: A and B may be used where the grade is sufficiently below the top of the wall; C, installation where the grade is close to top of wall; D, intake built between joists and equipped with automatic valve; E, same kind of intake built on mow floor

and where for any reason the duct can not be extended downward at least 3 feet on the inside. The arrangements shown in B and C are preferable to method A as they provide greater assurance against back drafting since warm air at the ceiling of the stable is trapped. The outer intake openings of an installation as shown in E are to be seen above the windows in Figure 14. More detailed information regarding the construction and use of intakes will be found in Farmers' Bulletin 1393 (*5*).

HAY CHUTES

Open hay chutes prevent regulation of stable ventilation and temperature since the warm stable air escapes into the mow above. Stable air should not be vented into the mow because the hay absorbs moisture from the stable air. As the warm, moisture-laden air comes into contact with cold air in the mow or with cold roof surfaces, the moisture is condensed and deposited on the hay and on roof timbers. If the outside temperature is very low, frost may be formed. Under

favorable conditions spontaneous ignition may occur in hay so wetted. Moisture on the underside of the roof causes rotting of timbers and shingles. Not only does the warm air escape into the mow but during winter nights cold and heavier air drops from the mow into the stable causing drafts which may readily be the cause of sickness among the stock. Separate outtake flues such as previously described should be provided for the ventilation of cow stables.

Open hay chutes are also undesirable because in case of a mow fire burning hay may drop into the stable, or if fire originates in the stable the open chute permits a draft which fans the flames. In either case the chance of saving the stock is greatly lessened.

STALLS AND EQUIPMENT

Good stall-floor construction is the first essential in stable sanitation. Without proper drainage no stall-floor construction can be

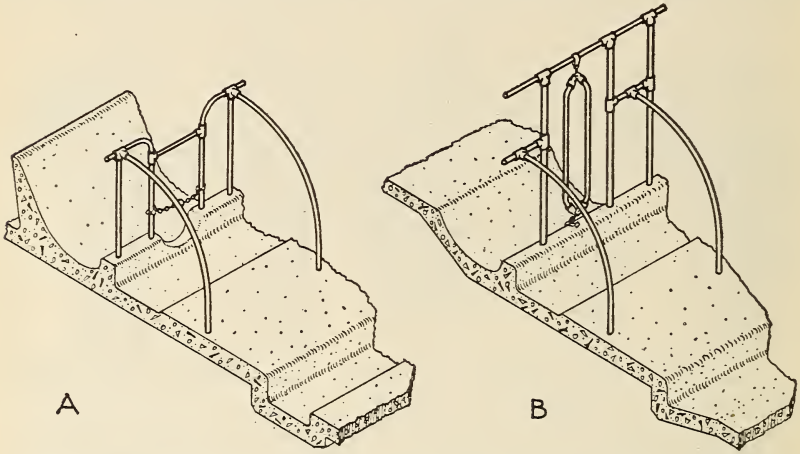

FIGURE 20.—Concrete dairy-barn floor: A, High-backed manger and rectangular gutter; B, manger flush with feed alley floor and beveled gutter. The latter is desirable where the litter alley is narrow, and for ease in cleaning

considered good. Dirt floors, very common in the region surveyed, can not be properly drained, and as a result gutters become foul and wet, and the stalls afford excellent harborage for bacteria and vermin. Because such floors are difficult to clean they are neglected, and the consequence is dirty cows and a stable filled with foul air. Where an attempt is made to keep a stable with such floors clean, the extra labor involved would go a long way toward paying for better construction.

Figure 20 illustrates two methods of flooring. The high-backed manger in A prevents the pushing or throwing of feed by the cows into the alley, and the possibility of their being injured by slipping and falling, as they strain after feed that is out of reach. Another advantage afforded by this manger is that the alley floor may be made level with the stall-floor, thus gaining a little headroom where ceilings are low. Directions, with dimensions, for the construction of dairy-barn floors are given in Farmers' Bulletin 1480 (*1*) and Farmers' Bulletin 1342 (*7*).

It is not always feasible for an owner to lay a complete new and properly designed floor in his barn at one time, but it is possible to do it a little at a time. As the first step, the complete gutter

FIGURE 21.—Finishing a concrete floor laid in an old barn. Note use of wood float to obtain rough surface

with the rear half of the stall floor may be laid with the proper pitch to the drain outlet. It is advisable to lay this much at one time in order to avoid joints where liquid may accumulate. The manger and stanchion curb may then be laid, but before the concrete is placed, all pipes, drains, stanchion sleeves, uprights, and anchor bolts should be set accurately in the forms. The front part of the stall floor should be the next step, and then either the feed or litter alley, or both. Figure 21 shows how one progressive dairyman improved his barn. In this case, the stall floor, gutter, and litter alley were laid at one time, the old wooden partitions and mangers being left until funds were available for new stall equipment.

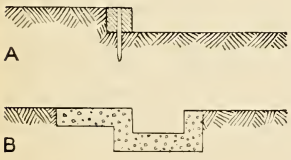

FIGURE 22.—Methods of temporarily improving a dirt stall floor: A, Use of a heavy timber to retain stall floor; B, concrete gutter which may be made part of a permanent floor

The least that can be done to improve a dirt floor is shown in Figure 22. In A a 6 or 8 by 8 inch timber is laid at the rear of the stall and held in place by iron rods or lengths of pipe driven into the ground through holes bored in the timber. In this way the cows, when lying down, are kept out of the gutter and are much

more easily cleaned. The arrangement should be considered only as a temporary makeshift to be replaced by a proper floor as soon as possible. B shows the more desirable method, as the concrete gutter may be made the first step in the laying of a complete sanitary floor.

STALL ARRANGEMENT

In modern dairy barns of the type in most general use the cow stalls are arranged in two rows parallel to the length of the building and facing either toward a center feed alley or toward the outside walls. As compared with stall rows crosswise of the stable, this arrangement saves time and labor in feeding, handling, and caring for the stock. A recent investigation indicates a saving of 30 per cent or more. If the barn is placed with the long axis approximately north and south and if windows are provided on both sides, each part of the stable gets the benefit of sunlight during some part of the day. In such a barn good air circulation with comfortable temperature is more easily maintained than in the bank type of structure.

In a great many of the barns surveyed the cow stalls were in rows across the barn. When such light as enters the stables comes from one side this arrangement has one advantage, in that the alleys in both the front and the rear of the stalls are lighted to some extent if there is no overhang, or one of very slight projection. Very often there is no inside communicating passage between the rows of stalls. In some instances there is a passage along the inner or bank wall. The stock at the inner ends of the rows receive little or no light and fresh air.

In the remodeling of old bank barns the rearrangement of stalls depends upon the dimensions of the stable, the overhead construction, and the number and kind of stalls or pens to be provided. Every instance of remodeling is an individual problem. In some the stable is not wide enough to permit of two lengthwise rows of stalls. In others the position of girders and supporting posts is such that in any rearrangement of stalls they would compel a break in the range of stalls or obstruct one or more of the alleys. Steel girders and steel-pipe columns, occupying much less space than the old heavy timbers and permitting greater spans between supports, have been installed in a few barns. Existing wooden posts sometimes may be shifted to allow proper stall spacing. Figure 15 shows one method of avoiding the interference of a supporting post with a stall. Figure 23 is a plan of the same barn. Originally the stalls were in crosswise rows. In the new arrangement the stalls were placed as near the outer wall as possible to obtain the greatest benefit from the light admitted through the windows installed as shown in Figures 14 and 15 and to keep the stock away from the inner side of the stable, which is still dark and damp since it was not possible to insert windows or fresh-air inlets on that side.

Another example of an improved but still unsatisfactory stable is shown in Figure 24. Information with regard to the original stall arrangement was not available, but evidence of change was to be seen in the location of girder supports, in the steel girders which replaced wooden timbers, in the concrete floors, in new windows

under the overhang and at one end, and in ventilating flues which had been recently installed. The barn was clean and without undue odors. The lighting was by no means ideal because of the overhang, a feature which in this case could not be overcome without

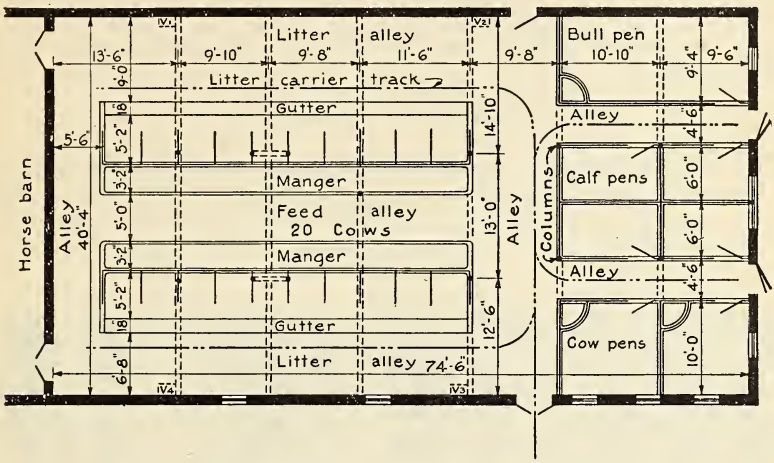

FIGURE 23.—Rearrangement of stalls in a barn 40 feet wide

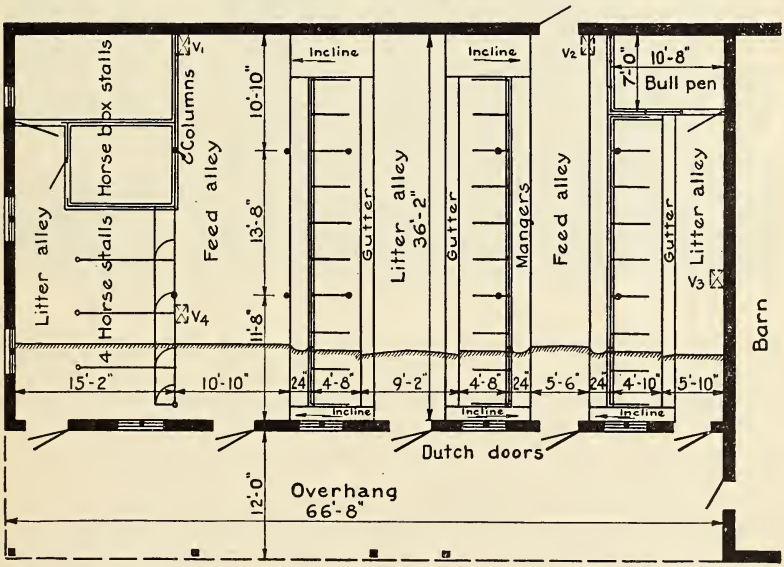

FIGURE 24.—Plan of barn in which conditions were greatly improved but which still has objectionable features

considerable expense. It would have been better had the horse stalls been placed at the other end, thus obtaining better light for the cow stalls.

If horses must be housed in the same stable with dairy cows, they should be separated by a tight partition. In many localities horses are not permitted in the cow stable, and it would be well for

dairymen of the region under consideration to anticipate the possibility of such requirements becoming effective and in remodeling to arrange horse stalls so that they may be removed easily.

The location of the bull pen is particularly objectionable, as it is the darkest and least ventilated part of the stable. Health and vigor in a bull is essential to the welfare of the herd. If kept for any length of time in quarters such as this he can not be expected to remain healthy.

STALL FASTENINGS AND PARTITIONS

The old rigid wooden stanchions in which cows were imprisoned for long periods of time are no longer used by good dairymen. They have been replaced by modern swinging stanchions or ties which permit the cows more freedom of movement and allow them to rest in a natural position.

FIGURE 25.—Interior showing swinging stanchion in a wooden frame

The stall equipment shown in Figure 25 was made by home labor at small cash outlay. The swinging stanchion, which may be had in wood, steel, or steel lined with wood, is desirable because of the comfort it affords the animal. If erected with hired labor the cost is not much less than that of complete commercial steel equipment which is considered the more sanitary.

Two types of modern fastenings are shown in Figure 20. That shown in B is the type of stanchion commonly used in modern dairy barns and is provided with secure but easily operated locks at the top. The partitions prevent the animals from soiling the adjacent stalls and from stepping on one another's udders. Stanchion adjusters may be had which permit adjustment of about 6 inches in length of stall. They are useful only when the stall platform is too long.

Chain ties are comfortable and inexpensive and have been used widely in connection with the old wooden-box mangers, but, because of the freedom of movement they allow, the animals are more likely

to lie in their own filth than when some other ties are used. A proper tie must not only hold the cow securely, but it must also aid in keeping her clean through reasonable restriction of movement. Figure 20A illustrates an improved type of chain tie in which a chain is attached to sliding rings on standards placed about 18 inches apart. A neck band on the cow is secured to the chain by means of a strong snap. The crossbar above the chain is adjustable as to height and serves to force the cow to the back of the stall when standing. It combines the comfort and freedom of the old chain tie with the sanitary qualities of the steel stall and can be purchased at about one-half the cost of the type shown in B. In another form of tie the old-style chain with a toggle-bar fastener is used.

WATER BOWLS

It has been found that under otherwise equal conditions dairy cows which have free access to pure water produce more milk than those watered irregularly or only at certain hours of the day. The automatic water bowl at each stall provides the best means of supplying the cow with water when she wants it and has been found to be a profitable investment. The bowls must be of a good substantial type and properly placed. If they are placed too high the cow has difficulty in drinking and frequently is forced to lap the water out of the bowl. If placed too low she will sometimes place a foot on the valve lever and thus flood the stall. The proper height varies with the size of the cow. In general they should be placed from 26 to 28 inches above the floor for Jerseys and other small breeds, and from 28 to 30 inches for Holsteins.

LITTER CARRIER

The modern litter carrier is another paying investment since it saves from one-half to two hours labor per day, depending upon the size of the herd, in cleaning the stable. The tight tub of the carrier prevents the dripping of liquid upon the alley floors, an objection to the use of wheelbarrows or manure spreaders in the barn, and thus reduces the amount of cleaning that must be done. The carrier saves many steps since it holds a great deal more litter than does a wheelbarrow. As it is suspended from a trolley with roller-bearing wheels on an overhead track, the effort required to move the carrier is much less than that required to push a wheelbarrow.

Litter carriers can be installed only where there is sufficient headroom to permit of walking under the track. For stables with low ceilings carriers are available which consist of a tub mounted on wheels and arranged for attaching to a track conveyor and hoist at the entrance door.

Figure 14 shows one type of swinging track crane by means of which the carrier is conveyed to a manure pit, manure spreader, or to one or more piles at a distance from the barn.

HAYMOW FRAMING

Figures 26 and 27 illustrate a suggestion for the changing of typical haymow framing so that hay may be stored more quickly. The crossbeams in the central bay, shown in Figure 26, may be

omitted since they are not necessary when the side bays are properly braced. Where the rafters are of a single length, as is usually the case, the old purlins and inclined supporting posts can be removed and replaced by new purlins and posts, as shown in Figure 27. The old purlins and knee bracing, if in good condition, can be placed in the new position, but new posts spliced to the old posts below will be necessary.

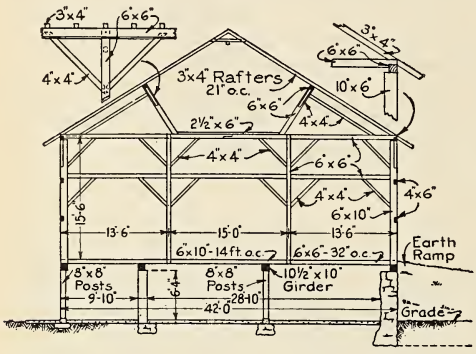

FIGURE 26.—Cross section of typical haymow framing

This arrangement permits the use of an adjustable rope or chain on the hay fork when the mow is filled from the mow floor, making it unnecessary to hoist each forkful of hay to the top of the mow. By discarding the driveway and inserting a hay door at one end of the barn the storage capacity of the mow would be greatly increased. In many barns, such as that shown in Figure 5, the extra space thus gained in the mow would permit the removal of an overhang to provide better lighting in the stable below.

REPAIRS

A large number of barns visited during the survey were badly in need of repair. Whether improvements such as have been suggested are to be made or not, repairs should be made, particularly when failure of a supporting member may jeopardize the whole or a large part of the structure. A small expenditure now may save a heavy expenditure later.

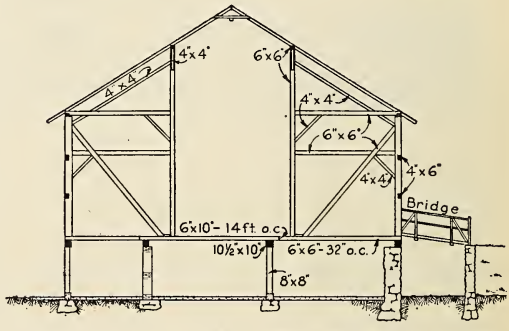

FIGURE 27.—Remodeled framing of the mow shown in Figure 26 which expedites use of hay fork from mow floor or permits mowing of hay from outside through hay doors installed in gable walls

All walls and structural timbers should be examined for soundness. Timbers which show signs of rotting should be replaced. Cracked walls should be carefully pointed up or filled with cement grout. Rough wall surfaces should be made smooth by the application of cement plaster. The surfaces to be plastered should be first thoroughly cleaned with a stiff brush and then roughened and moistened. A dry surface will absorb moisture from the cement mortar and prevent proper setting and bonding. Bulging walls should be rebuilt. Water seepage through walls should be prevented.

Moisture and warmth are conducive to rot in timbers. Moisture collects in dairy stables that are not properly ventilated. Where

timbers are exposed to the weather and moisture can enter cracks or joints, rotting soon occurs. In such places, particularly at or close to the ground, creosoted lumber should be employed. Lumber treated with creosote under pressure can be obtained in many localities. Where it is not available the dipping process, though not so effective, may be used. Farmers' Bulletin 744 (4) describes methods of treating timbers.

In many of these old barns the mow floor is supported on wooden girders, cross girders, joists, and in some instances a second layer of joists. This network of timbers affords many places for the lodgment of moisture and is difficult to ventilate. While these timbers generally are in a good state of preservation, the housing of dairy cows without adequate ventilation will doubtless cause early deterioration. Where such floor construction shows need of replacement, or where additional headroom would be desirable, steel beams may be substituted, thus saving unnecessary timbers, adding to the headroom, and often greatly improving the distribution of light. When moisture or ammonia gas, as in horse stables, is present, all steel work should be coated with a good barn-equipment paint to prevent corrosion and consequent unsightliness.

SUGGESTED REMODELING OF A BARN

No two of these old barns are exactly alike in size, construction, contents, or surrounding conditions, so that recommendations for the remodeling of one will not apply entirely to another. Yet suggestions applicable to one set of conditions should be valuable to one considering the remodeling of his own barn. It is with this in mind that the conditions existing in a particular barn (fig. 28) and suggestions for remodeling to meet the requirements of the owner are presented. The result is not ideal, but it is a great improvement on the present stable conditions and should enable the owner to produce milk at less cost for labor.

Since the owner, for the present, will not require additional hay storage and is limited as to funds, he will retain the use of the mow driveway and will make no change in the roof framing, which is practically the same as that shown in Figure 26. The present arrangement of the stable is shown in Figure 29. The herd is to be increased by three cows, and the horses are to be reduced in number. By rearrangement, the present stable space is sufficient. Although the lighting could be improved by inclosing the space under the overhang and substituting posts and girder for the brick wall, the expense would hardly be warranted. The proposed remodeling is shown in Figure 30.

The ceiling of the stable is lower than is desirable, since with the added dairy stock the volume of air space is very little in excess of the 500 cubic feet per cow, which in many States having regulations is the minimum requirement. In some States 600 cubic feet is the minimum. The headroom could be increased, thus improving both the air conditions and the lighting; but it would be necessary to raise the superstructure of the barn about 18 inches, since the ground south of the barn is level, and the additional height could not be gained by lowering the floor. In view of the small number

of stock to be housed, the expense of raising the ceiling would not be warranted.

Like most of the old bank barns of the section the overhang is on the south side which, if the sunlight is not obstructed, is the best exposure. As the overhang is to remain, it is desirable that the cows be placed at the west end, which has the next best exposure. By installing additional windows at this end the lighting of the cow stalls will be greatly improved.

It will be noted that one of the posts supporting the longitudinal girder in the old plan would obstruct the feed alley in front of the horse stalls of the new plan. This is overcome by inserting new

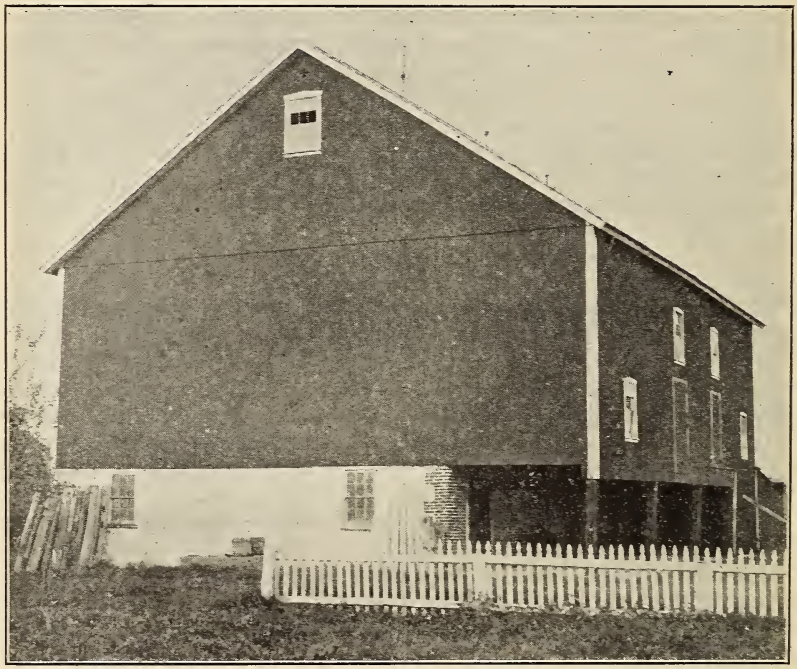

FIGURE 28.—Frame barn with 10-foot overhang supported on posts and which was to be remodeled in accordance with the plan shown in Figure 30

posts with a short crossbeam under the large girder somewhat as shown in Figure 15.

In the new arrangement the cow stalls are a little wider than necessary owing to the location of the supporting posts. An additional stall could be inserted in the inner row by reducing the width of the stalls, support for the girder being provided as at the horse stalls.

The rearrangement of stalls necessitates the moving of the partition between the stable and implement shelter about 1 foot to the east, still permitting the operation of the sliding implement-shelter door. Even with the space thus gained, the width of the litter alley between the cow stalls will be a little less than might be desired. It is also necessary to make changes in the door and window openings

in the wall under the overhang. A window in the east wall will light the otherwise dark northeast corner.

One-half of the double mow driveway should be abandoned, thus making it possible to excavate a part of the wide ramp and to insert a window in the bank wall, which will provide additional light and air circulation in this part of the stable.

The present hay chute, close by the door leading to the silo, should be changed to the location shown in the new plan so that the alley between the pen and the bank wall will be clear for feeding either hay or silage. In remodeling the cow stalls, which are but 3 feet wide, the present wooden box mangers and stall partitions should be discarded and new stall equipment including water bowls provided, together with a concrete floor throughout. Owing to the low ceiling a litter carrier could not be installed in the litter alley, but the type of carrier having a detachable tub on wheels with an overhead track from the alley door to the manure pit would be a great convenience.

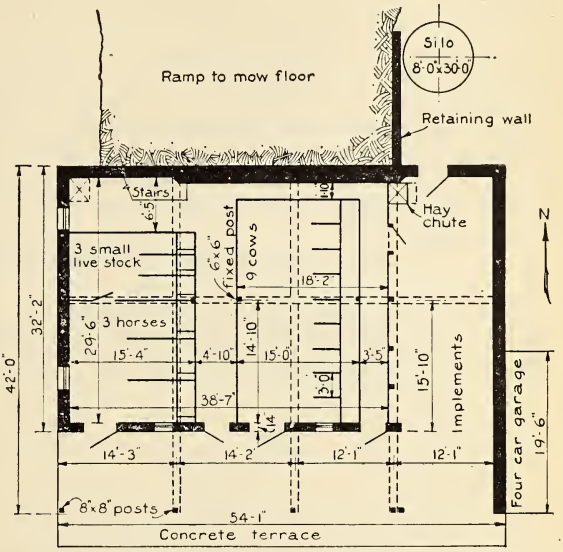

FIGURE 29.—Plan of existing dairy stable which is to be remodeled

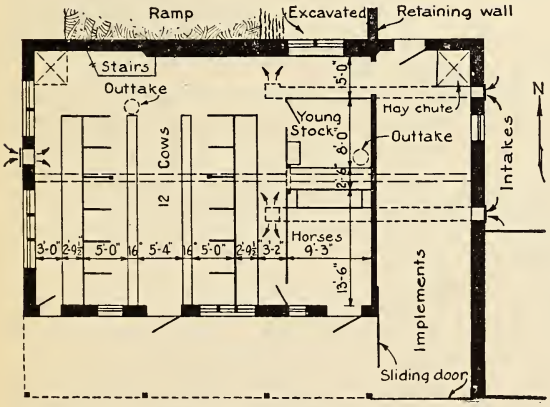

FIGURE 30.—Suggested rearrangement of plan shown in Figure 29

Because of the small volume of air space per head in the stable, ample ventilation is especially necessary. During mild weather fresh air may be admitted through the doors and windows. Fresh-air intakes with automatic dampers for use during cold weather should be installed in the locations shown on the new plan. The outlet of the intake on the right and nearest the bank wall should direct the incoming air toward the wall so as to stimulate circulation at this point when the windows are closed.

The position of the west outtake, shown in Figure 30, is determined by the location of the driveway above. The flue is placed so that it avoids the beams at the side of the driveway.

All the changes suggested for this particular barn can not be applied to all barns of the kind, but the improvement is obvious to anyone studying the two plans. This illustration of what can be done, together with the preceding general suggestions, should enable anyone interested to take stock of the conditions existing in his own barn and to work out means of improving them. Where funds are limited it is well to make changes a step at a time and not wait until all the work can be done at once. A dollar spent in improvements of this kind produces a continuous return in added convenience and saving of time and labor in doing the barn work and in the health of the stock.

NEW BARN CONSTRUCTION

When a barn that has been destroyed by fire or otherwise is replaced by a new structure, the tendency is to use the old foundation and often the old methods of framing. The use of old foundations, if in good condition, saves expense, but it generally means that the new barn is no better than the old so far as light, ventilation, and arrangement are concerned. Changes such as those suggested in the preceding pages would make for improvement, but it would be much better to build on entirely different plans, using, perhaps, a part of the old foundation, or building on a new site.

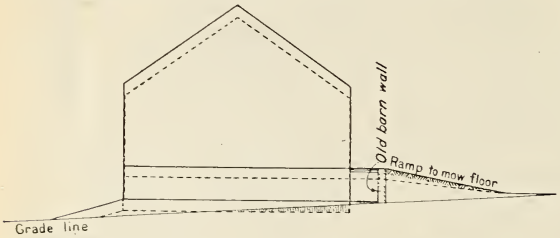

FIGURE 31.—An instance of advantage to be gained, in reconstruction on old site, through consideration of ground levels. Solid lines show the location and levels of new construction. Dotted lines show levels that might have been used

When a new barn is to be erected on an old site, advantage should be taken of the opportunity to obtain more light and air on the north or bank side by setting the new structure 8 or 10 feet away from the old bank wall as shown in Figure 31. In planning such a change in location consideration should be given the grade levels in order to avoid the situation shown in the illustration, which represents a condition observed in a number of instances where barns were rebuilt or enlarged.

When the new barn was built the old floor level was retained, making necessary a heavy inside fill of 3 or 4 feet at the south side of the stable. The earth for the fill had to be hauled from another site. Owing to the location of the barn lot on the south side and on account of the arrangement of cow stalls, entrances on the south side were required. Because of the difference in levels, steep ramps or runways for the stock, an undesirable feature, became necessary.

Had the floor level been lowered by excavating on the north side, as shown by the shaded area in the illustration, and the excavated earth used for filling on the south side, no hauling of earth would

have been necessary, and a very small ramp would have served at the south doorways. The driveway could have been graded to a lower grade, making an easier haul into the mow.

The extent to which the floor may be lowered in such a case depends upon the depth of the footings of such portion of the old walls

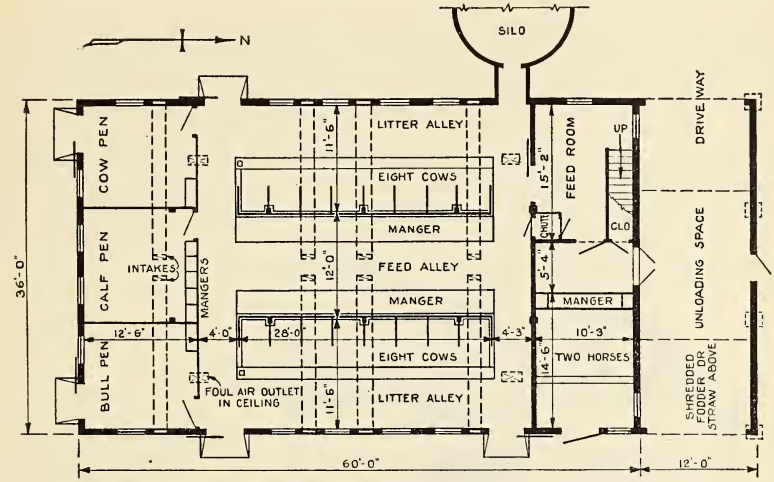

FIGURE 32.—Plan of modern barn with the north end against a bank

as may be retained. Had the old walls been torn down and new footings and foundations provided, the floor might have been placed at a still lower level. This would have been desirable had the slope of the ground been greater, or if a wider barn had been wanted.

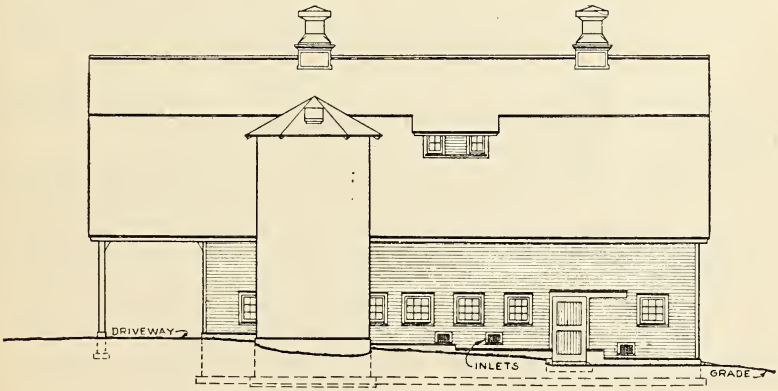

FIGURE 33.—Side elevation of barn shown in Figure 32

Owing to the conformation of the land, which is rolling and often very hilly, a level site for the barn is not always available. If the building must be set into a slope or bank it is better, if the grades will permit, to face it with the long axis north and south and with the north end against the higher ground as shown in Figures 32 and 33. In this way all the stock will have sunlight during some part of the day, and the whole stable may be well ventilated.

If the grades are such that outside entrances to the pens at the south end are not feasible, they may be omitted and the pens may be entered from the cross alley. Or the pens may be floored at a lower level, thus avoiding some of the fill. If the pens are not needed, they may, of course, be omitted. The barn could then be shortened by 10 or 12 feet.

The haymow may be filled from the high ground at the north end by the use of modern hay-handling equipment. If a sheltered driveway is desired, the main roof may be extended as shown in the illustration. This permits of a smaller haymow, since the usual mow drive is omitted, and saves the heavy floor construction required for a mow drive. The relation between the level of the drive and that of the mow floor will depend upon the slope of the ground, which will also determine the amount of masonry work in the barn walls. The building should not be set so far into the bank as to cut off light and air at the sides of the north end of the stable.

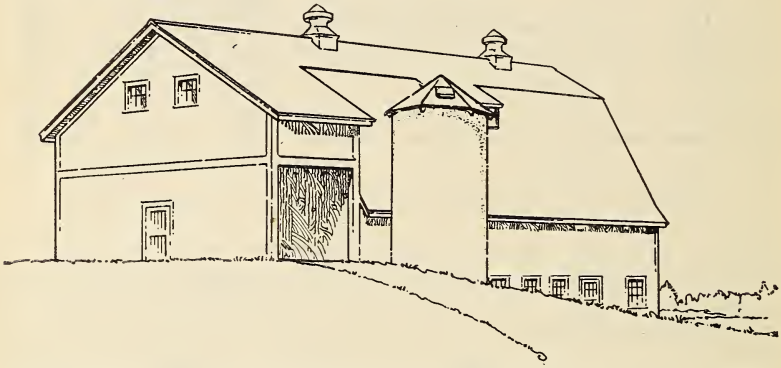

FIGURE 34.—Perspective view of barn shown in Figure 32 but with roof changed to accord with the higher driveway level

If the grade of the driveway is but a foot or so below the mow floor level, the roof may be constructed as shown in Figure 34, thus obtaining the necessary headroom for a load of hay.

It is a common practice of southeastern Pennsylvania to stack corn near the barn, to be husked as need or as opportunity offers. In the arrangement shown the corn may be stacked to the north of the drive, and when husked may be stored in a near-by crib or thrown through an opening in the drive wall to the feed alley or feed room below.

If for any reason the barn must be placed with the long axis parallel to a hillside, the bank should be excavated only to such depth as will permit of light and air on the bank side of the stable, as shown in Figure 17.

No one dairy-barn plan will meet all the varied conditions to be found on the farms of this area. Figures 32, 33, and 34 are based on a design, prepared in the United States Department of Agriculture, Washington, D. C., which, with modifications, meets the general requirements of the average dairyman of the area under consideration. The building may be made longer or shorter, and the interior arrangement may be changed to conform to the particular requirements of the individual owner. Complete working drawings of the design

upon which these illustrations are based, together with a bill of materials, may be had upon application to the Bureau of Agricultural Engineering, Washington, D. C.

SUMMARY

It is necessary that a great many of the old bank dairy barns, to be found in certain milk-producing areas of the Middle Atlantic and North Central States, be improved in order that they shall comply with the housing requirements set up by regulatory authorities in large centers of milk consumption.

The most serious objection to the old barns is the lack of light, ventilation, and cleanliness. Poor arrangement and want of modern time and labor-saving equipment account for high operating and maintenance charges.

Although few of these old barns can be made ideal at a reasonable cost, a very large proportion of them may be remodeled so as to provide the principal requisites of an acceptable cow stable, namely, an abundance of clean and always available water, fresh air night and day, exposure to sunlight, protection from heat and cold, ample space for the stock, easily cleaned floors, and equipment to facilitate the care of the cows.

As the conditions in these old barns vary widely specific recommendations for remodeling, applicable to all, can not be made. Suggestions of more or less general application are offered, together with illustrations of remodeling which has been done and which may serve by way of inspiration to those who wish to remodel their old barns.

The beneficial effect of sunlight depends upon the number, size, and arrangement of windows, thickness of walls, height of ceiling, and the character of interior wall surfaces with respect to light reflection. The amount of glass required is usually stated as "4 square feet per stall" or "1 square foot per 25 square feet of floor space." These do not insure adequate lighting unless the glass is properly distributed. The lighting of stables in barns having an overhang generally may be improved by removing the overhang or extending the stable to the outer wall of the overhang. In the latter case the stalls should be arranged along the new outer wall.

As much of the dairy barn work is done before sunrise and after sunset ample artificial lighting makes for speed and efficiency in getting the chores done. It has been shown that good lighting reduces the time 25 to 40 per cent.

A good ventilating system is necessary in order that the products of respiration may be removed, that clean fresh air may be introduced without drafts, and that wall and other surfaces and feed stuffs may be kept dry. Ventilation by means of open windows may be practiced in mild weather. Ventilation in cold weather necessitates the installation of suitable intake and outtake flues placed so as to produce an even distribution of fresh air. Hay chutes should be closed since, if left open, they prevent regulation of stable ventilation.

Good concrete stall and alley floors are the first essentials of proper sanitation.

Wherever possible stalls should be arranged in two rows parallel to the length of the stable and facing a center feed alley or the outside walls. This arrangement saves time and labor in feeding, handling, and caring for the stock.

It is not desirable to house horses in the cow stable and in many localities it is not permitted unless they are separated from the cows by a tight partition.

Old rigid wooden stanchions should be removed and replaced with modern swinging stanchions or ties. An automatic water bowl should be installed at each stanchion so that the cow may have water when she wants it.

A modern litter carrier should be installed wherever it is feasible, as its use saves from one-half to two hours' labor per day in cleaning the stable, depending upon the size of the herd.

The mow driveway common to old bank barns may often be abandoned to advantage. The space thus gained may be used for hay or straw storage, thus permitting the removal of an overhang which keeps sunlight from the stable. The installation of a large door in one end of the mow and modern handling equipment will often save time and labor in storing hay.

When a barn is being remodeled to meet regulatory requirements, repairs should be made wherever needed. Particular attention should be given supporting members, the failure of which might cause serious damage.

LITERATURE CITED

(1) Betts, M. C., and Miller, T. A. H.
1926. small concrete construction on the farm. U. S. Dept. Agr. Farmers' Bul. 1480, 38 p., illus.

(2) Covert, R. N.
1926. protection of buildings and farm property from lightning. U. S. Dept. Agr. Farmers' Bul. 1512, 33 p., illus.

(3) Holman, H. P.
1925. painting on the farm. U. S. Dept. Agr. Farmers' Bul. 1452, 33 p.

(4) Hunt, G. M.
1916. the preservative treatment of farm timbers. U. S. Dept. Agr. Farmers' Bul. 744, 32 p., illus. (Revised, 1928.)

(5) Kelley, M. A. R.
1924. principles of dairy-barn ventilation. U. S. Dept. Agr. Farmers' Bul. 1393, 22 p., illus.

(6) National Fire Protection Association.
——. national electric code. regulations of the national board of fire underwriters for electric wiring and apparatus. (Revised every two years.)

(7) Parks, K. E.
1923. dairy-barn construction. U. S. Dept. Agr. Farmers' Bul. 1342, 22 p., illus.

(8) Warren, G. M.
1929. making cellars dry. U. S. Dept. Agr. Farmers' Bul. 1572, 29 p., illus.

ORGANIZATION OF THE UNITED STATES DEPARTMENT OF AGRICULTURE WHEN THIS PUBLICATION WAS LAST PRINTED

Secretary	ARTHUR M. HYDE.
Assistant Secretary	R. W. DUNLAP.
Director of Scientific Work	A. F. WOODS.
Director of Regulatory Work	WALTER G. CAMPBELL.
Director of Extension Work	C. W. WARBURTON.
Director of Personnel and Business Administration.	W. W. STOCKBERGER.
Director of Information	M. S. EISENHOWER.
Solicitor	E. L. MARSHALL.
Weather Bureau	CHARLES F. MARVIN, *Chief.*
Bureau of Animal Industry	JOHN R. MOHLER, *Chief.*
Bureau of Dairy Industry	O. E. REED, *Chief.*
Bureau of Plant Industry	WILLIAM A. TAYLOR, *Chief.*
Forest Service	R. Y. STUART, *Chief.*
Bureau of Chemistry and Soils	H. G. KNIGHT, *Chief.*
Bureau of Entomology	C. L. MARLATT, *Chief.*
Bureau of Biological Survey	PAUL G. REDINGTON, *Chief.*
Bureau of Public Roads	THOMAS H. MACDONALD, *Chief.*
Bureau of Agricultural Economics	NILS A. OLSEN, *Chief.*
Bureau of Home Economics	LOUISE STANLEY, *Chief.*
Plant Quarantine and Control Administration	LEE A. STRONG, *Chief.*
Grain Futures Administration	J. W. T. DUVEL, *Chief.*
Food and Drug Administration	WALTER G. CAMPBELL, *Director of Regulatory Work, in Charge.*
Office of Experiment Stations	————, *Chief.*
Office of Cooperative Extension Work	C. B. SMITH, *Chief.*
Library	CLARIBEL R. BARNETT, *Librarian.*

This circular is a contribution from

Bureau of Public Roads	THOMAS H. MACDONALD, *Chief.*
Division of Agricultural Engineering	S. H. MCCRORY, *Chief.*

U. S. GOVERNMENT PRINTING OFFICE: 1931

For sale by the Superintendent of Documents, Washington, D. C. - - - - - Price 10 cents